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PROGRESS REPORT

Evaluation of Skylab Imagery as an Information Service for Investigating Land Use and Natural Resources, (Skylab) NASA Contract: NAS 9-13364.

(E75-10013) EVALUATION OF SKYLAB IMAGERY AS AN INFORMATION SERVICE FOR INVESTIGATING LAND USE AND NATURAL RESOURCES Progress Report, Oct. 1974 (Cornell Univ.) 12 p HC $3.25 CSCL 08B

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This report covers the period from October 1 - 31, 1974. During this period, emphasis was placed on the first parts of the user survey and in completing a large part of the photographic techniques.

The questionnaire for the Data/Information Requirements Survey was pretested with the Broome County Planning Department on October 25. Broome County is located in New York's Southern Tier, outside of the three areas selected for the survey. It encompasses approximately 714 square miles and had a population of 221,815 in 1970. As a result of this pretest, certain ambiguous questions were identified, and appropriate corrections and additions were made to the questionnaire.

On October 31 and November 1, introductory sessions were held with officials and staff of the Planning Departments of Orange, Dutchess, and Ulster Counties - the three counties that comprise the Lower Hudson Valley test area. In addition, introductory sessions were held with the planner for the Town of Warwick in Orange County, representatives of the Environmental Management Coucils of Orange and Ulster Counties, and a wildlife biologist with the Cary Arboretum (a division of the New York Botanical Gardens).

These introductory sessions were intended to acquaint the potential users with Skylab and ERTS imagery, to demonstrate the Resource Information Laboratory's process for multispectral analysis, and to discuss the advantages and limitations of this type of analysis and satellite imagery in general. A follow-up session is planned some three to four weeks later to determine user requirements for areal data more definitively.

The development of photographic enhancement techniques has progressed along two avenues. In the first case, we have attempted to carefully balance the enlarged black and white spectral bands for contrast and density so as to maximize the interpretability of the information in the different bands. In this way, we can provide for the best color balance when the black and white densities are converted to diazo hues and we can also standardize the darkroom procedure to insure reproducible results. Secondly, we have found it necessary to investigate to the extent we can the characteristics of the diazo film. To this end we were interested in defining what reproducible results could be expected. We have recorded the physical characteristics of the GAF film in terms of spectral composition and density relationships. In an attempt to minimize ambiguous interpretation, a computerized color prediction model has been developed as reported in the September progress report. This model maximizes the color contrast in the diazo composites for selected areas based on the black and white density inputs for those areas on the different spectral bands. A determination of the accuracy of interpretation using this model is now in progress.

An attempt to compare ERTS and Skylab imagery of a common area recorded within 21 days of one another, using the diazo process for the final hard copy comparison, included the following steps:

ERTS: Accession No. 1403-15120, August 30, 1973, bands 4, 5 & 7.
In general the same procedures as reported in the Progress Report of January 15, 1974, entitled - "Photographic Enhancement of ERTS Imagery" was followed.*

*National Technical Information Service #E74-10259

a. 3X enlargements on Kodak polycontrast paper from 70 mm black and white positives indicated the initial trial exposures and development time necessary for balanced negatives on Kodak projection plates.

b. 3X enlarged negatives from bands 4, 5 & 7 were produced on an Omega D-3 auto focus enlarger using an 80 mm f5.6 Rodenstock lens.

Data as follows: Medium Projection Plate

					Gamma
Band 4	f 16	7 sec.	DK-50	4 min.	1.62
Band 5	f 16	18 sec.	DK-50	2 min.	1.22
Band 7	f 16	9 sec.	DK-50	2 min.	1.22

c. From negatives in (b) above, matching prints on polycontrast paper were made.

d. Positives 8" x 10" film transparencies on commercial film developed in D-19 were made so that an enlargement of 13.58 resulted in a scale of 1:250,000.

Data as follows:

				Gamma
Band 4	1.0 sec.	D-19	5 min.	1.45
Band 5	.6 sec.	D-19	5 min.	1.45
Band 7	1.0 sec.	D-19	5 min.	1.45

e. The positives were duplicated by contact on diazo film to produce "false color" on a GAF #240 Diazoprinter with a speed control calibrated to 60 steps.

Data as follows:

Band 4	speed 3	Yellow
Band 5	speed 5	Magenta
Band 7	speed 3.5	Cyan

<u>SKYLAB:</u> SL3-S190A, rolls 44, 47 & 48*, frame 236, September 19, 1973.

Direct projection positives were made from 70 mm negatives to match the area and scale of the ERTS imagery in the equivalent spectral bands as in (d) above. The enlarger was a Kodak Precision A modified with a Leitz 2" condenser and a Kodak 2" f4.5 projection Ektar.

f. Polycontrast 8" x 10" enlargements that matched the ERTS prints in (a) above resulted from the following treatments:

Band 4	12 sec.	no filter
Band 5	10 sec.	"
Band 7	10 sec.	"

*Green light (roll 48) is designated band 4, red light (roll 47) is designated band 5 and 800-900 nanometer infra-red (roll 44) is designated band 7.

g. The original commercial film positives, exposed 10% the polycontrast time and developed uniformly in DK-50, were unsatisfying and the final exposures and developments were satisfactory.

				Gamma
Band 4	1.4 sec.	D-19	9 min.36 sec.	1.65
Band 5	1.3 sec.	"	7 min.12 sec.	1.5
Band 7	1.3 sec.	"	6 min.	1.5

h. Printed on diazo film with the same procedure as described in (e) above.

Band 4	speed 4	Yellow
Band 5	speed 5	Magenta
Band 7	speed 7	Cyan

The comparison between ERTS and Skylab shows a remarkably close correlation between the two methods of enhancing and enlarging imagery. Skylab is easier to manipulate 1) because of the need for only the single enlargement to produce the film positives to the described scale and 2) because of the close balance and quality of the negatives furnished by NASA. By contrast, the ERTS imagery furnished had to go through a two-step film correction process to correct exposures, densities, and contrasts before the finally acceptable film positives were achieved.

Experiments were conducted with the color 5" x 5" positives from the terrain camera in the Skylab SL-3 mission coverage of the Hudson Valley and Long Island. True color was used for Long Island and false color (infra-red) for the Hudson Valley. The intent was to reproduce isolated areas and reproduce the originals using the diazo process at a scale of 1:24,000, an enlargement of approximately 40X. (Long Island color - S190B-SL3 roll 88 frame 277; Hudson Valley - IR S190B-SL3 roll 87 frame 299.)

Briefly, the procedure was to photograph the original using Wratten filters #29, 61 and 47B on Super XX film at about 6X. From these negatives approximately 6+X transparencies were made on commercial film. These in turn were used to print on diazo material.

In general, the results leave much to be desired for the following reasons:

1. It is questionable whether the duplicate color can be enlarged this much with the resolution essential for good interpretation.

2. All components in the system are stretched to their capacity.

3. Unmasked, the color although a reasonable facsimile of the original, leaves much to be desired.

New trials at half scale (1:48,000) were tried and produced results easier to interpret.

Data on trials:
Both areas received the same treatments.

LONG ISLAND

Red #29	filter	6 sec.	Super XX film	D-19	7 min.
Green #61	filter	3 sec.	"	"	7 min.
Blue #47B	filter	6 sec.	"	"	12 min.

A new trial with a 10X negative on Super XX film is underway that may prove better at a lesser scale.

HUDSON VALLEY

Red #29	filter	5 sec.	Super XX Film	D-19	7 min.
Green #61	filter	3 sec.	"	"	7 min.
Blue #47B	filter	6 sec.	"	"	12 min.

These negatives are slightly less dense and when printed on commercial film to a higher contrast may improve on the first trials.

Polycontrast print from red filter, negative made with no filter - time - 3 sec.

Film transparencies made as follows:

Red #29	.3 sec.	commercial film	DK-50	dev	8 min.
[1]Green #61	.3 sec.	"	"	"	8 min.
[2]Blue #47B	.3 sec.	"	"	"	8 min.

[1]Densitometer indicated correct exposure @ .336 seconds.
[2]Densitometer indicated correct exposure @ .24 seconds.
(Timer could not split time this fine).

Experiments are in process to mask both terrain camera positives with a single contrast and color correcting mask with red filter #29, or magenta filter #33. Currently far greater detail seems possible with better color but the full process has not been detailed. In general, the contrasts have been lowered too much.

In an attempt to indicate some of the variations inherent in diazo films, it has become standard procedure to expose a density step wedge with each batch of diazo film processed. The GAF 8 1/2" x 11" diazo films of magenta, cyan and yellow were exposed and developed on a GAF Diazoprinter #240, which used a voltage regulator and a finely calibrated exposure dial (60 steps). Standard procedures were followed to keep the machine set at the same exposure speed and heated ammonia flow rate for each test over a eight month period.

Tentative results from various film lots and packages show that there is a fairly wide range of density variation between sheets of film. GAF diazo film researchers indicated in a personal communication that the film variation is ± 10%. Results to date, with the above outlined tests, have shown a saturation density variation of ± 10% from an average of 43 yellow film samples, ± 14% from an average of 36 cyan samples, ±16% from an average of 35 magenta samples (see graphs 1 - 3).

It also became apparent that full saturation density could only be achieved when some samples were run up to 4X longer in the ammonia developer than the exposure time. This is in contrast to the manufacturer recommendations that the film be developed at the same speed as the exposure speed.

Two different film lots of cyan, magenta and yellow were exposed and developed to saturation, then measured on a photospectrometer to determine the visible spectrum transmission characteristics. Variations in the relative dye purity of these samples point out some potential problems in the subtractive film procedure used for composite construction. The changes in the shape of the curves, as seen in graphs 4 and 5, are the important indication of dye purity alterations.

The characteristic curve (log exposure vs. density) of each diazo film for different exposure settings changes between packages and on different days. What percent of this variation is due to the film sensitivity and what percent is due to the #240 GAF diazoprinter is not known at this time.

From these tentative results it has become apparent that further more controlled tests would be necessary to determine what variations in the final film are due to variations in either the film manufacturing or the diazoprinter exposure and development. The tests have shown variations in film dye purity, dye quantity and dye sensitivity, but we are unable to positively determine the source of the variations as either the film or film processing. There is somewhat less variation between packages of film from the same lot than between film lots. Maintaining standard processing procedures will minimize these variations. However, further tests would require a diazoprinter with all of the following attachments and precautions for each test: 1) voltage regulator, 2) temperature control on developer, 3) fine calibrated exposure dial, 4) ammonia flow rate tests, 5) photometer tests on lamp output, 6) tachometer tests to insure the film transport speed accuracy, and 7) tests to check for full development of film.

The film to be used in these tests would have to be tested for age, temperature, dye saturation, dye sensitivity, dye purity, and protected from handling that may cause premature exposure and/or development. It is probable that such extensive tests could require the close cooperation of the manufacturer. No further tests of this nature are planned.

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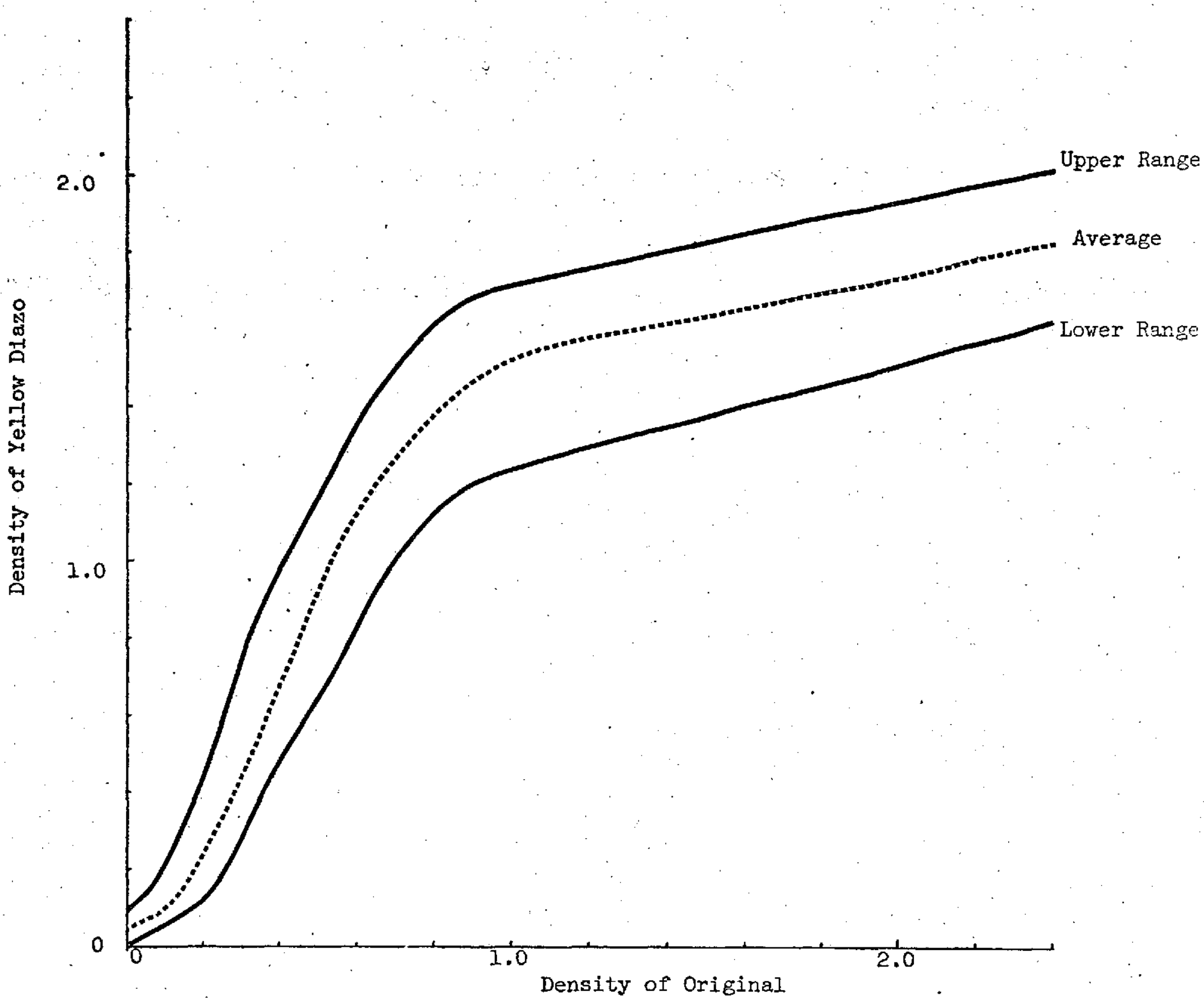
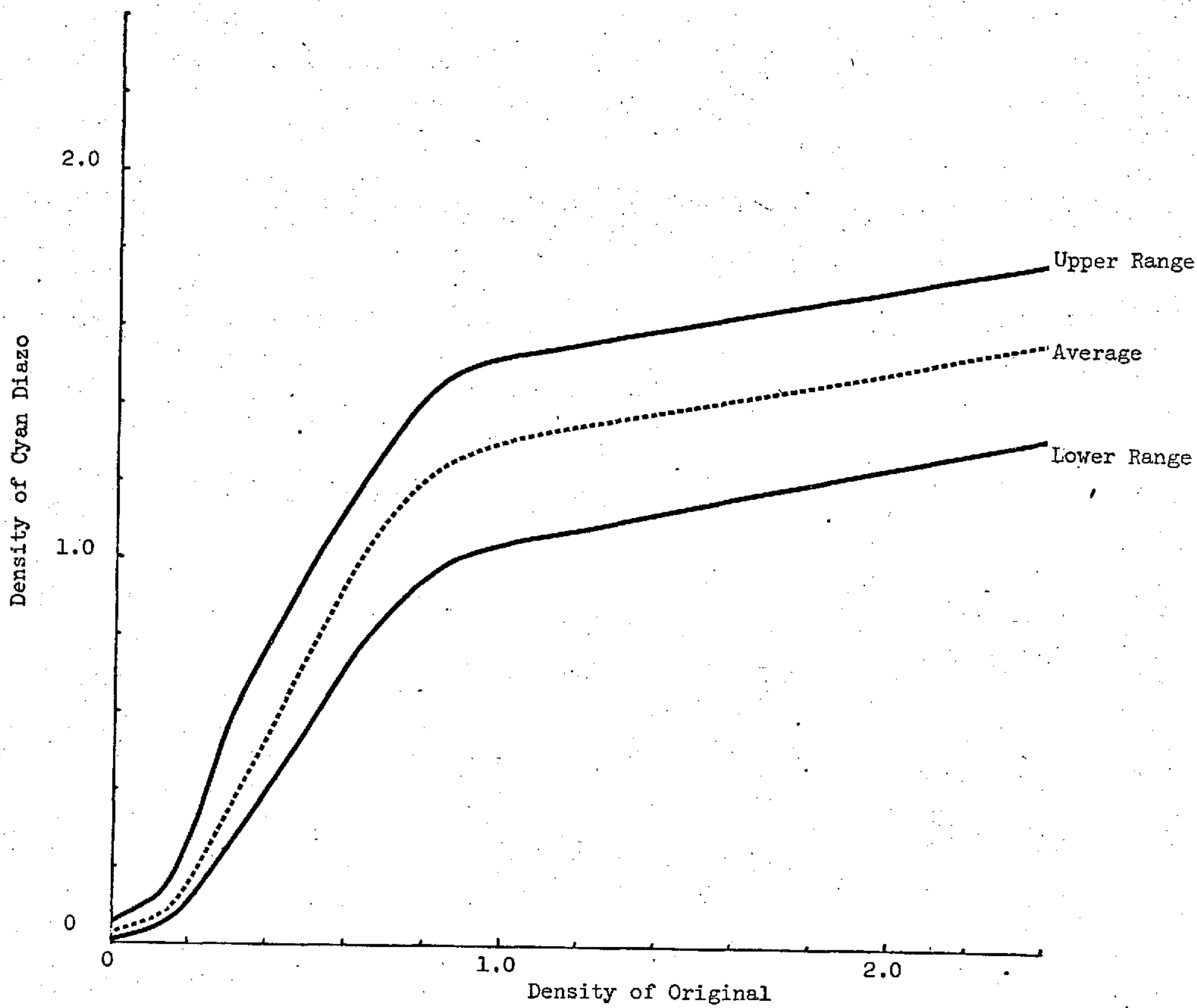
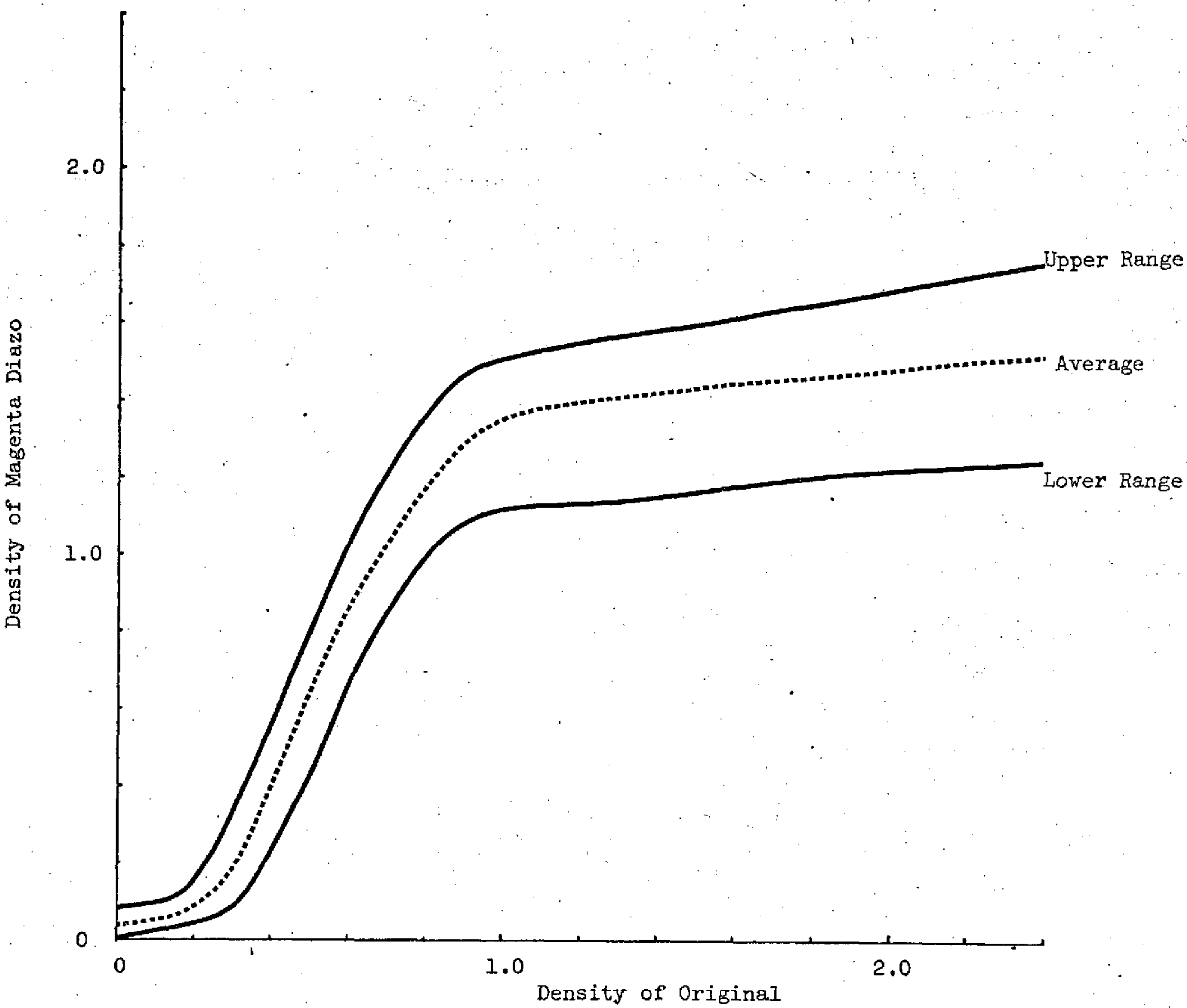


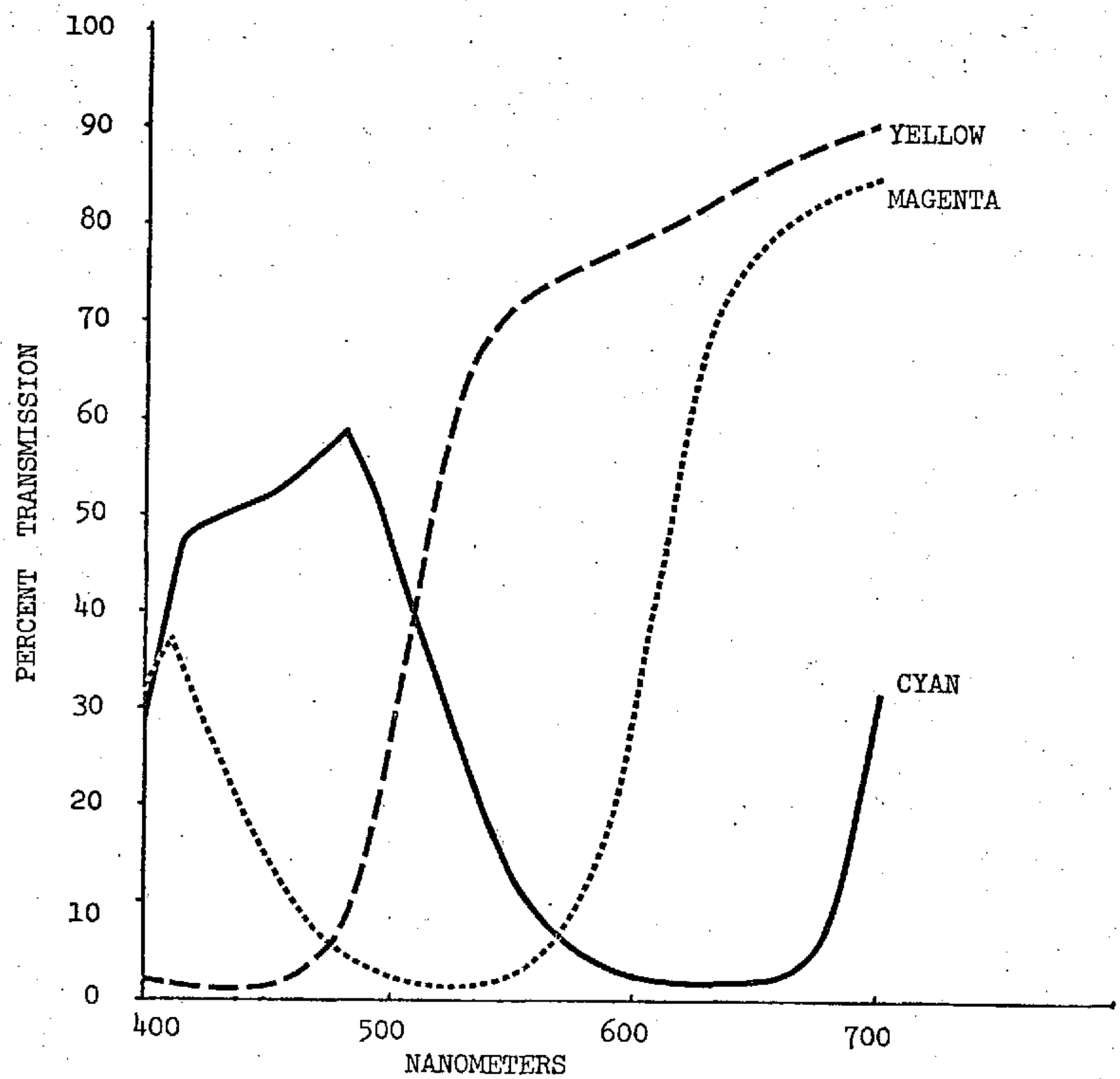
Graph 1. Yellow diazo (GAF) film characteristic curve for one specific exposure and development setting shows a ± 10% variation from the average at saturation. The data was collected from 43 samples and 4 different film lots.



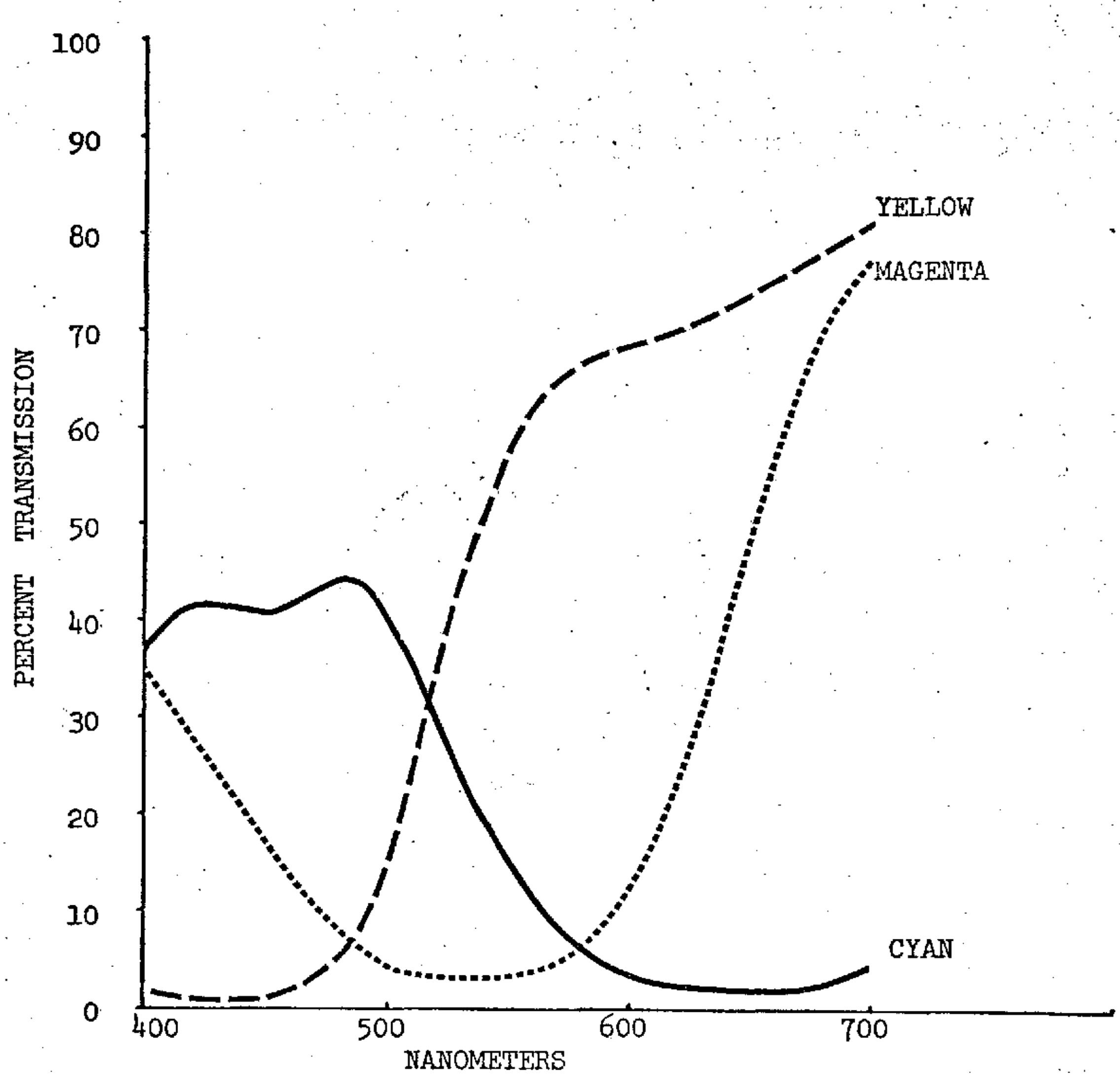
Graph 2. Cyan diazo (GAF) film characteristic curve for one specific exposure and development setting shows a ±14% variation from the average at saturation. The data was collected from 36 samples and 3 different film lots.



Graph 3. Magenta diazo (GAF) film characteristic curve for one specific exposure and development setting shows a ±16% variation from the average at saturation. The data was collected from 35 samples and 2 different film lots.



Graph 4. The transmission characteristics of three diazo films (GAF) measured at 10 nanometer intervals (sample 1).



Graph 5. The transmission characteristics of three diazo films (GAF) measured at 10 nanometer intervals (sample 2).